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- Experience relevant to remediation of Peconic River sediments.

- Phytoremediation of DDT and chlordane

Peconic River Sediments*

Class	Contaminant	Max. conc. (mg / kg)
Inorganic	**Hg**	**24.5**
	Ag	**171**
	Cu	**1140**
Organic	**PCBs (*arochlor 1254)***	**1.5**
	DDD	**0.096**
	DDE	**0.089**
	α-chlordane	**0.073**
	γ-chlordane	**0.043**
	endosulfan	**0.018**

* Proposed Plan for Operable Unit V Peconic River/Sewage Treatment Plant Brookhaven National Laboratory (www.bnl.gov)

Outline

- Phytoremediation of organic chemical contaminants

- Greenhouse study for soils contaminated with chlorinated insecticides (*DDT/DDD/DDE + chlordane*)

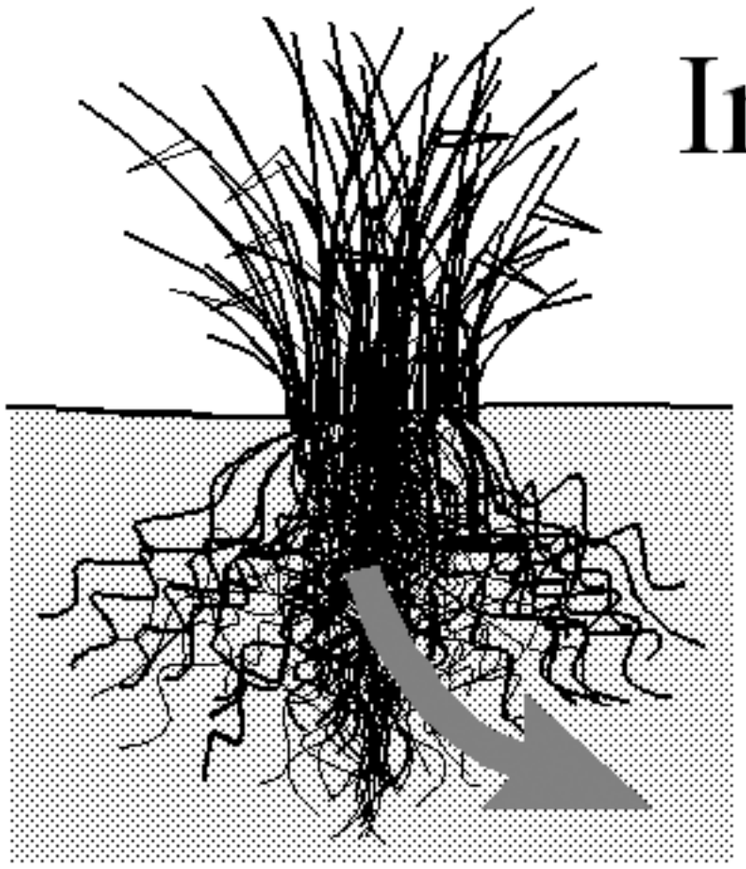
Phytoremediation of organic chemical contaminants in soils and sediments

- Enhanced biodegradation in the rhizosphere

- Plant uptake and metabolism of certain contaminants

- Contaminant immobilization (e.g. humification)

Rhizosphere: Zone of Soil Influenced by Plant Roots



- Plant root exudates – a food source for microbes
  - *Sugars, organic acids, nucleotides, flavonoids, enzymes*
  - *Sloughed-off cells, mucilagenous material*
- General increase in microbial cell numbers
  - *100 to 1000-fold greater than bulk soil*
  - *Mycorrhizal fungi*
- Diverse species of microbes brought together at high population density
  - *Enhance stepwise transformation*
  - *Genetic exchange*

Light micrograph of pseudomonads

Rhizosphere: Other Factors Enhancing Contaminant Biodegradation

Exudates may stimulate co-metabolism

Mulberry trees exude phenolic compounds (e.g. flavonoids)

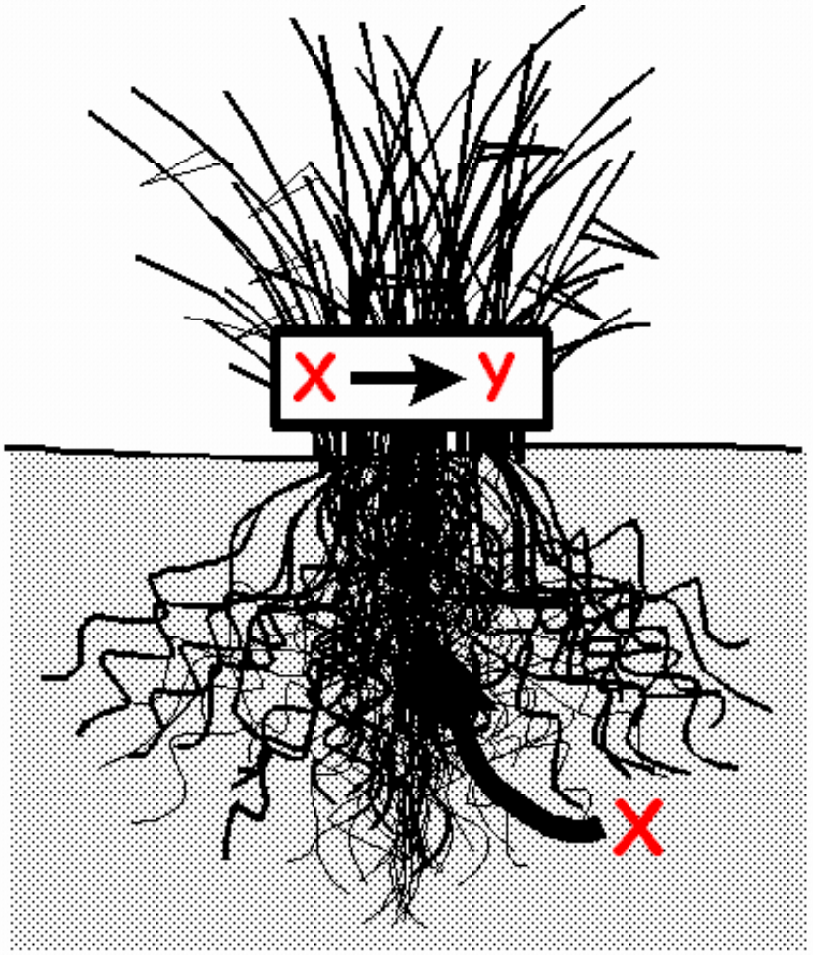
Specifically stimulate PCB-degrading microbes (Fletcher et al.)

Exudates may contain surfactant molecules

Enhanced biodegradation in the root-zone

- Petroleum hydrocarbons
- Polyaromatic hydrocarbons
- Pesticides
- Herbicides
- Chlorinated solvents
- Explosives

Plant Uptake and Metabolism of Organic Contaminants



- Plants take up moderately hydrophobic compounds - - some undergo transformation
- DDT/DDD/DDE + chlordane
  - very hydrophobic
  - excluded

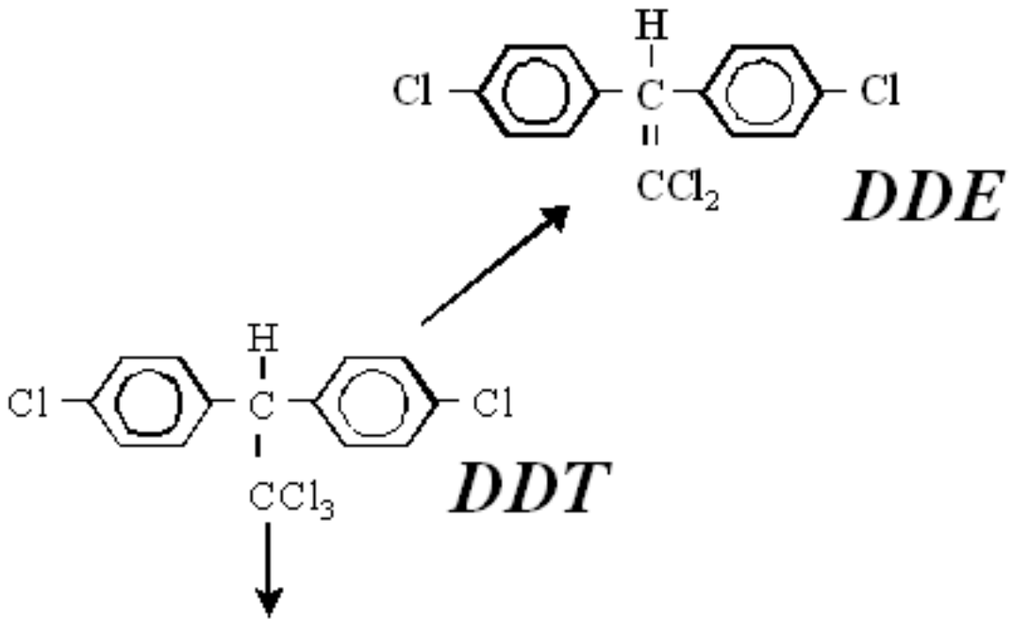
Greenhouse Study -- Protocol

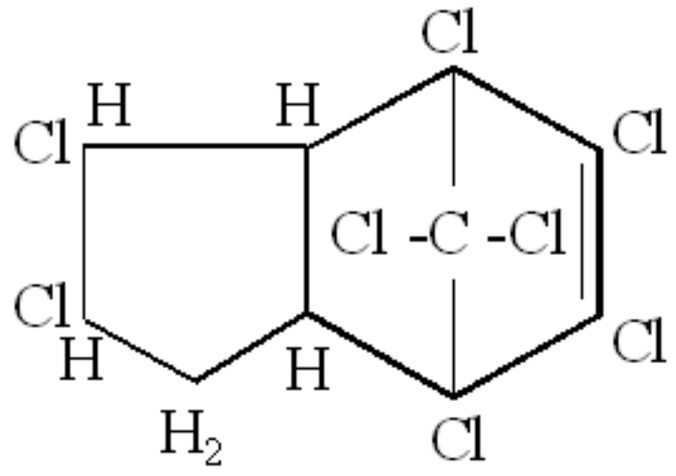
- Plant establishment – 5 weeks
- Treatment: flood aerobic cycles (8weeks/cycle)
- Controls
  - Anaerobic – columns maintained under flooded conditions
  - Aerobic – columns maintained under aerobic conditions
- Triplicate sets of columns harvested at intervals (61, 116, 172 days)
- Soils extracted; gas chromatographic analysis of extracts

Contaminant Immobilization in Planted Systems

- Sorption of hydrophobic contaminants to plant roots ("phytostabilization")
- Formation of "bound residues" in plant roots
  - *Non-extractable; sequestered in lignin fraction*
  - *Examples: TNT, PCP, pesticides*
- "Humification" – formation of covalent (non-extractable) complexes with humus
  - *Oxido-reductase enzymes on external root surface (e.g. peroxidases, lacasses)*
  - *Enzyme oxidation can polymerize xenobiotics into soil humic fraction (e.g. chlorinated phenols)*

Greenhouse treatability study for soils contaminated with chlorinated insecticides





Chlordane

DDT→DDE under aerobic conditions

DDT→DDD under anaerobic conditions

DDX = DDT + DDD + DDE

Greenhouse study

- Contaminated soils from an East coast industrial site
- Preliminary phytotoxicity study to select tolerant plants

Species	**DDT**			
	(mg / kg)			
	<0.5	**50**	**145**	**605**
Redtop (*Agrostis alba*)	++++	++++	-	-
Deertongue (*Panicum sp.*)	+++	++++	+	-
Reed Canarygrass (*phalaris arundinacea)*	+++	++++	++++	++
Canadian bluegrass (*Poa compressa)*	++++	++++	+++	+

Greenhouse study – experimental system

- Contaminated soils
  - Soil A (145 mg DDT/Kg)
  - Soil B (50 mg DDT/kg)
- Soil columns planted with reed canarygrass
- Objective -- Test hypothesis that biodegradation of organochlorine insecticides can be stimulated by repeated flooded/aerobic cycles

Soils used for the greenhouse experiment

Contaminant	Soil	
	A	B
	(mg/kg)	(mg/kg)
DDT	144.5	50.2
DDD	9.3	10.4
DDE	31.8	12.9
α-chlordane	196.4	27.7
γ-chlordane	221.2	29.4

Reed canarygrass

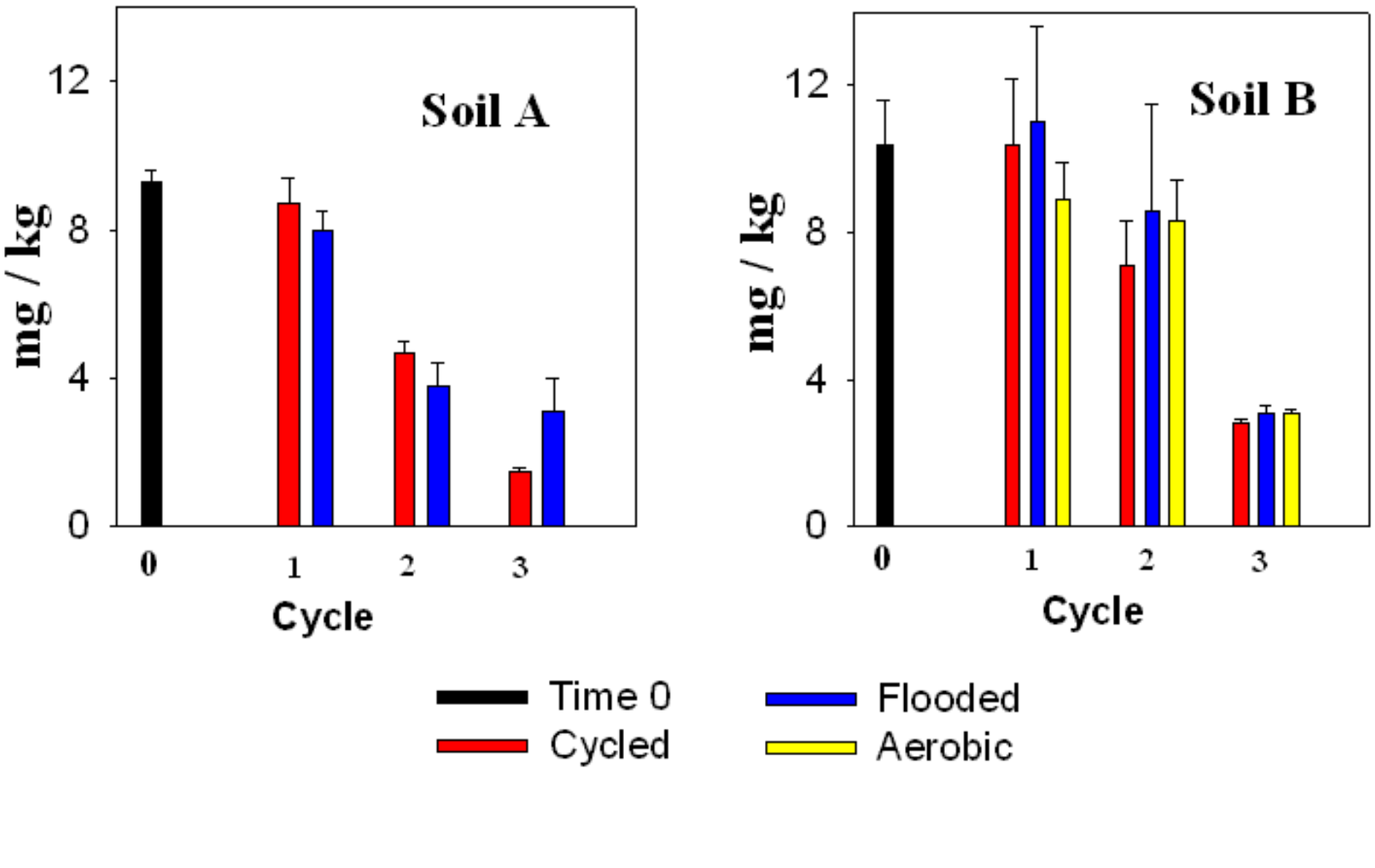
- Tolerant of the contaminated soil
- Native to Northeastern U.S.
- Wetland species
  - Tolerant of flood/well drained conditions
  - Provides cover for birds and wildlife

Greeenhouse Study – Protocol (continued)

- Triplicate sets of columns harvested at intervals (61, 116, 172 days)

- Soils extracted; gas chromatographic analysis of extracts

DDD


Soil A
Soil B
mg / kg
12
8
4
0
0
1
2
3
Cycle
Time 0
Cycled
Flooded
Aerobic

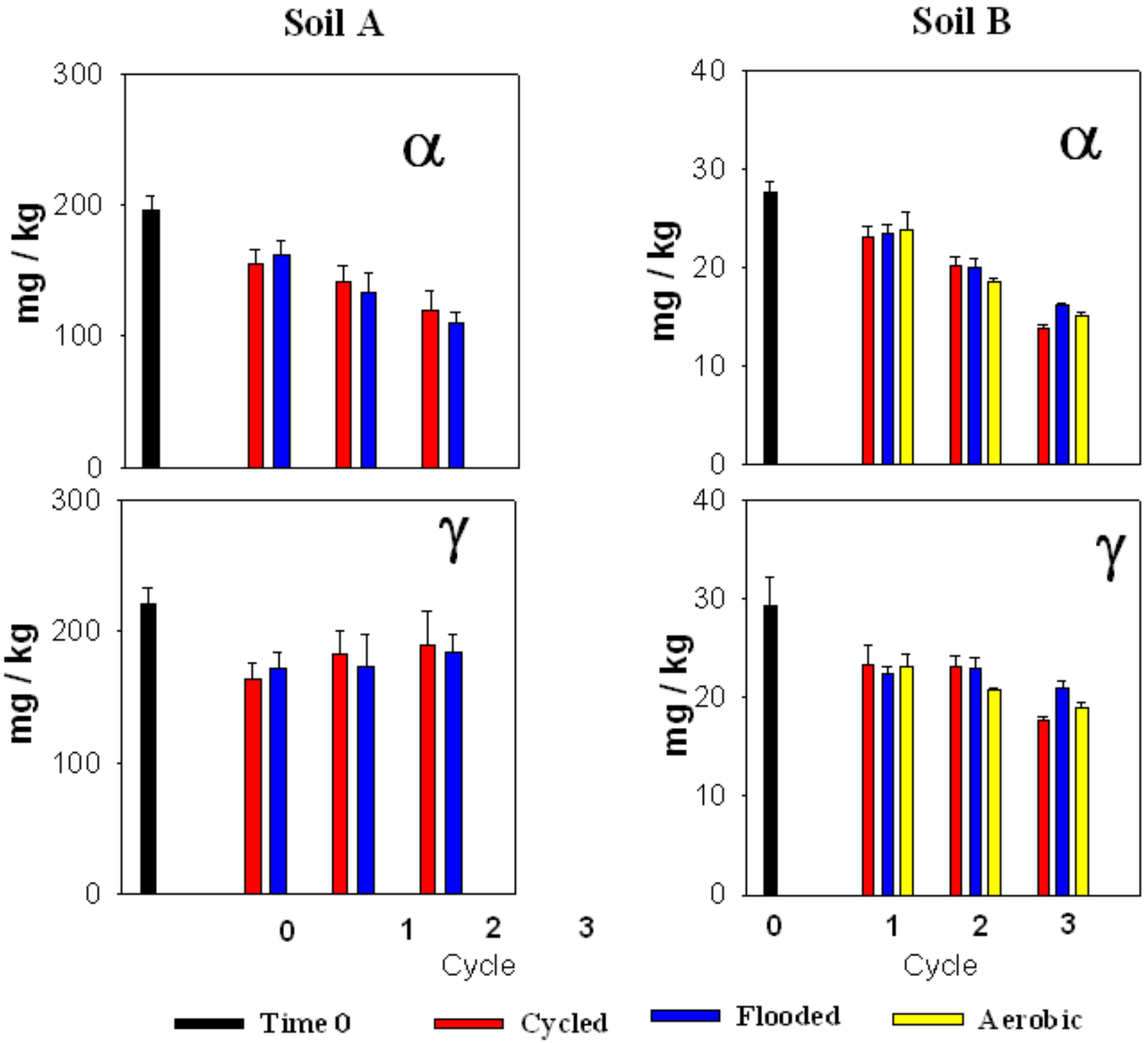
Conclusions from the Greenhouse Study

- Concentrations of DDD and DDE decreased with time in all treatments
  - DDE did not accumulate in the aerobic treatment
  - DDD did not accumulate in the flooded treatment
  - Concentration of DDX decreased with time

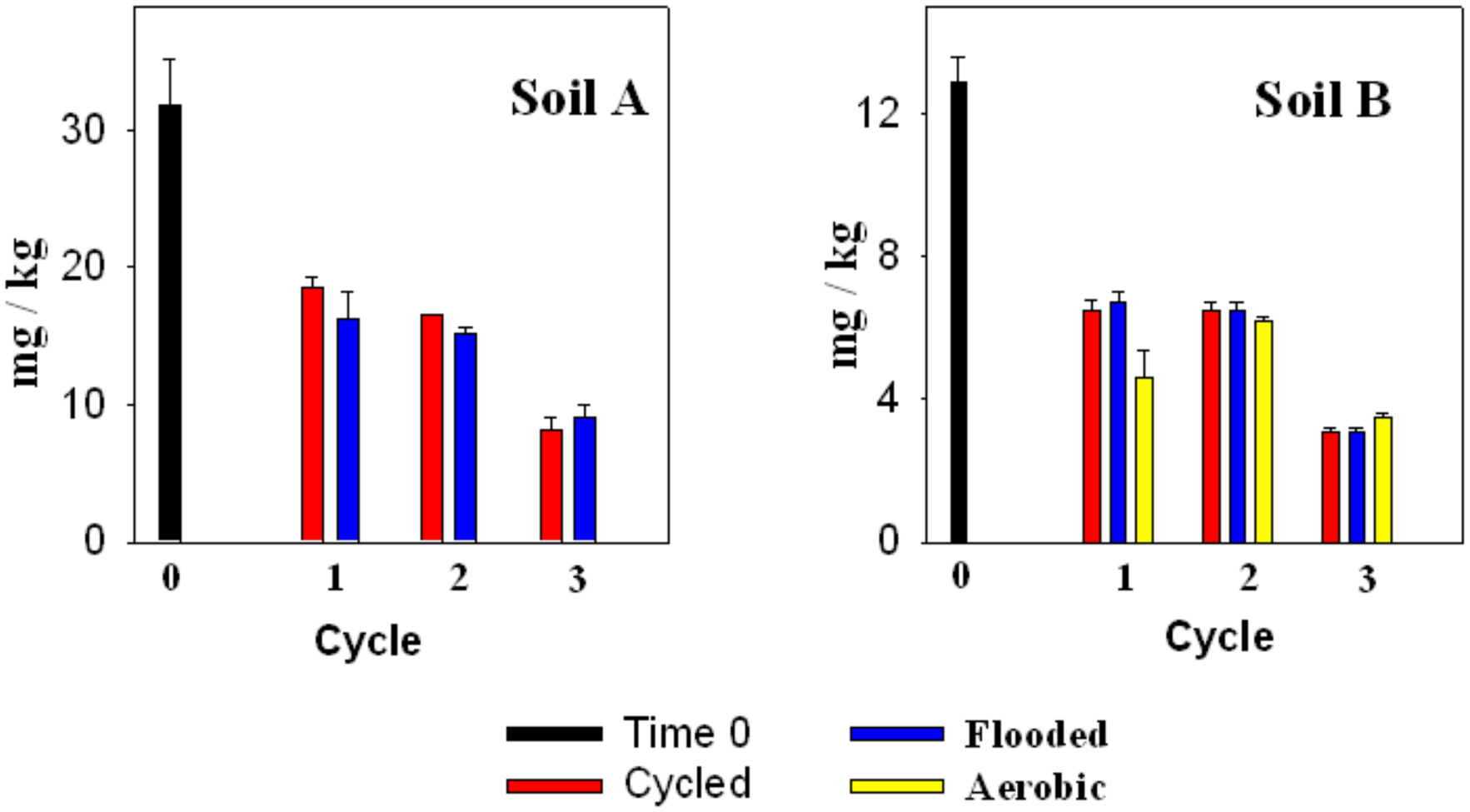
- Concentration of α-chlordane decreased with time in all treatment

- Significant treatment-specific effects were not generally observed *(no unplanted experimental controls were included in the study)*

Chlordane


Soil A
Soil B
α
γ
mg / kg
300
200
100
0
40
30
20
10
0
1
2
3
Cycle
Time 0
Cycled
Flooded
Aerobic

DDE


Soil A
Soil B
mg / kg
30
20
10
0
12
8
4
0
0
1
2
3
Cycle
Time 0
Cycled
Flooded
Aerobic